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Response of Perennial Grasses Potentially Used as Filter Strips to Selected Postemergence Herbicides[1]

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Abstract: Recent research at Mississippi State has shown that eastern gamagrass, switchgrass, and tall fescue grown as filter strips reduce herbicide losses in runoff from cotton. Field experiments were conducted in 1997 and 1998 to evaluate the response of these perennial grasses to postemergence drift and registered rates of glyphosate and paraquat in mid-April and clethodim, fluazifop-P, glyphosate, MSMA, pyrithiobac, quizalofop-P, and sethoxydim in early June. Results indicate that filter strip implementation will not simply involve establishment and maintenance. In most instances, reductions in harvested biomass were as high or higher than visual injury assessments in mid-June. This finding suggests an inability of these perennial grasses to recover from an accidental overspray or drift, within the year of the event. Management decisions must be made to protect the filter strips from contact with herbicides used in the production system to ensure filter strip integrity and survival.
Nomenclature: Clethodim; fluazifop-P; glyphosate; MSMA; paraquat; pyrithiobac; quizalofop-P; sethoxydim; eastern gamagrass, *Tripsacum dactyloides* L.; switchgrass, *Panicum virgatum* L. #[3] PANVI; tall fescue, *Festuca arundinacea* Schreb. # FESAR; cotton, *Gossypium hirsutum* L. # GOSHI.
Additional index words: Drift rates, filter strip integrity, runoff.
Abbreviation: POST, postemergence.

INTRODUCTION

Reduced water quality due to non–point source pollution is a current environmental problem receiving much attention (Misra et al. 1996). Vegetative filter strips are being used to reduce ground and surface water pollution from agricultural runoff (Arora et al. 1996). Vegetative filter strips are bands of planted or indigenous vegetation situated downslope of cropland or animal production facilities to provide localized erosion protection and to filter nutrients, sediment, and other pollutants from agricultural runoff (Dillaha et al. 1989). Because of the low installation costs, maintenance costs, and effectiveness in removing pollutants, conservation and regulatory agencies are encouraging the use of vegetative filter strips.

Previous research has documented the benefits of filter strips for managing agricultural runoff (Rankins et al. 2001). A 2-m-wide tall fescue filter strip reduced herbicide concentration in runoff in conventional and no-till soybean [*Glycine max* (L.) Merr.] production systems (Webster and Shaw 1996) and reduced surface runoff concentrations of fluometuron and norflurazon from cotton (Murphy and Shaw 1997). As much as 10% of applied fluometuron can be lost in surface runoff from conventionally tilled cotton (Baker et al. 1978). Switchgrass, when used as a vegetative barrier, facilitated infiltration of runoff water (Dabney et al. 1993a). Tingle et al. (1998) reported that vegetative filter strips reduced total runoff at least 83%.

Cotton is one of the most important crops in the southeastern United States. Several in-season herbicide applications may be required for adequate weed control in cotton production systems (Anonymous 1998; Bloodworth et al. 1999). Vegetative filter strips are usually established within or immediately adjacent to the crop. Thus, there exists potential for injury to the filter strip from herbicide drift or accidental direct topical herbicide applications. Perennial grass filter strips should be tolerant to herbicides used in the production system (Dabney et al. 1993b). Researchers reported general tolerance of seeded big bluestem (*Andropogon gerardii* Vitman) to soil-applied metolachlor (Griffin et al. 1988; Masters 1995). Peters et al. (1989) reported injury to seedling big bluestem, switchgrass, and tall fescue from postemergence (POST) applications of graminicides. How-

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[3] Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

ever, little data are available on the effects of POST herbicides on established stands of perennial grasses with potential as filter strips. With this in mind, research was initiated to evaluate the tolerance of several filter strip species to drift and registered rates of selected cotton herbicides commonly used in cotton production in Mississippi.

MATERIALS AND METHODS

Field studies were established in 1997 and 1998 at the USDA Natural Resources Conservation Service Jamie Whitten Plant Materials Center near Coffeeville, MS, and the Black Belt Branch Experiment Station near Brooksville, MS, to evaluate the tolerance of eastern gamagrass, switchgrass, and tall fescue to selected POST herbicides. The soil types were a Grenada silt loam (fine-silty, mixed, thermic Glossic Fragiudalfs; 2.0% organic matter, and pH 5.3 in Ap horizon) and an Oaklimeter silt loam (coarse-silty, mixed, thermic Fluvaquentic Dystrochrepts; 1.3% organic matter, and pH 5.3 in Ap horizon) at Coffeeville, and a Brooksville silty clay (fine montmorillonitic, thermic Aquic Chromuderts; 3.0% organic matter, and pH 6.6 in Ap horizon) at Brooksville. At Coffeeville, eastern gamagrass tolerance was evaluated on an Oaklimeter silt loam and switchgrass on a Grenada silt loam. Tall fescue tolerance was evaluated at Brooksville. Ideally, each perennial grass would have been evaluated on the same soil type; however, established stands (>5 yr of age) of these grasses were desired for this field experiment. A location large enough to conduct this experiment, with established stands of each grass on the same soil type was not found; thus, these grasses were evaluated on different soil types. Because of this limitation in the experimental design, direct comparisons across grass species were not made. Before initiating this experiment, these stands of perennial grasses were not subjected to herbicide applications, grazing, or tillage.

The plot size was 1.5 by 1.5 m for each study in both years. The experimental design was a randomized complete block with four replications. An untreated check was also included for comparison. The herbicides evaluated were clethodim (26 and 105 g ai/ha), fluazifop-P (39 and 158 g/ha), glyphosate (280 and 1,120 g/ha), MSMA (280 and 1,120 g/ha), paraquat (176 and 706 g/ha), pyrithiobac (17 and 70 g/ha), quizalofop-P (14 and 56 g/ha), and sethoxydim (70 and 280 g/ha). Higher rates were based on registered rates for cotton to simulate accidental topical applications. Lower rates, which were 25% of registered rates, were evaluated to simulate the higher end of drift rates. Twenty-five percent of the registered rate falls within the range of rates investigated in previous simulated drift studies (Bhatti et al. 1997; Eberlein and Guttieri 1994). At the initial application timing, ground cover ranged from 95 to 98% with each perennial grass species investigated. Application timings in mid-April and early June were investigated to correspond with preplant and at-planting burndown applications and in-season POST applications in cotton, respectively. Mid-April applications were made on April 9, 1997, and April 24, 1998, at Coffeeville and April 8, 1997, and April 23, 1998, at Brooksville. Plots were mowed approximately 3 wk before mid-April applications and were not subjected to additional mowing before harvest. Mid-April applications were made on approximately 30-, 60-, and 15-cm-tall eastern gamagrass, switchgrass, and tall fescue, respectively. Rainfall patterns and amounts were not atypical in either year. Early-June applications were made on June 4, 1997, and June 10, 1998, at Coffeeville and June 3, 1997, and June 9, 1998, at Brooksville. Early-June applications were made on approximately 110-, 150-, and 15-cm-tall eastern gamagrass, switchgrass, and tall fescue, respectively. Treatments were applied with a CO_2-powered backpack sprayer in 190 L/ha water at a pressure of 140 kPa. To minimize drift, boom nozzles were equipped with hoods, and there was a 1.5-m border between each plot. Crop oil concentrate[4] at 1% (v/v) was included in clethodim, fluazifop-P, quizalofop-P, and sethoxydim spray solutions. Nonionic surfactant[5] at 0.25% (v/v) was included with paraquat and pyrithiobac. Adjuvants were not added to glyphosate and MSMA treatments because a surfactant was included in the formulations used. Plots were hand-weeded throughout the season to prevent interference from other vegetation. Injury to grass species was assessed as reduction in visual and harvested biomass. Visual evaluations were taken at 2 wk intervals after the mid-April applications until early August on a scale of 0 to 100 based on chlorosis, necrosis, stunting, or general reductions in plant biomass (or all), where 0 = no injury and 100 = death of plants. A 0.93-m^2 area from each plot was harvested to quantify total biomass production on October 13, 1997, and October 25, 1998, at Coffeeville and November 1, 1997, and November 13, 1998, at Brooksville. Harvesting was executed by clipping

[4] Agridex, heavy range paraffin base petroleum oil polyol fatty acid esters, polyethoxylated derivatives, Helena Chemical Co., Suite 500, 6075 Popular Avenue, Memphis, TN 38119.

[5] Latron AG-98, a neutrally charged (nonionic) surface active agent, alkalaryl polyoxyethylene glycols, and alcohol, Rohm and Haas Company, Independence Mall West, Philadelphia, PA 19105.

Table 1. Effect of drift and registered[a] rates of selected herbicides on tall fescue injury and biomass production.[b]

Application timing	Herbicide	Rate	Visual injury		Harvested biomass[c] reduction
			Mid-June	Early August	
		g ai/ha	%		
Mid-April	Glyphosate	280	31	25	34
		1,120	72	67	40
	Paraquat[d]	176	26	31	35
		706	64	71	40
Early June	Clethodim[e]	26	16	25	36
		105	34	67	45
	Fluazifop-P	39	11	24	35
		158	32	62	41
	Glyphosate	280	31	32	42
		1,120	77	88	66
	MSMA	280	15	24	39
		1,120	50	44	41
	Pyrithiobac	17	0	17	30
		70	0	36	33
	Quizalofop-P	14	9	25	31
		56	26	69	45
	Sethoxydim	70	9	20	30
		280	27	41	37
LSD (0.05)			13	7	16

[a] Rates based on registered rates used in cotton.
[b] Means averaged over years.
[c] Based on 6,970 kg/ha biomass production for the untreated check.
[d] Nonionic surfactant at 0.25% (v/v) included in spray mix with paraquat and pyrithiobac.
[e] Crop oil concentrate at 1.0% (v/v) included in spray mix with clethodim, fluazifop-P, quizalofop-P, and sethoxydim.

shoots approximately 4 cm above the soil surface with a sickle bar mower. Shoot fresh weights were taken and converted to kilograms per hectare. Biomass data were converted to percent reduction of fresh weight compared with the untreated check.

Eastern gamagrass, switchgrass, and tall fescue injury and biomass reduction data were subjected to analysis of variance, testing all appropriate interactions. There were no significant treatment by year interactions; thus, data were combined over years. Tables appropriate for the interactions were constructed, and differences were compared by Fisher's protected LSD at the 5% significance level.

RESULTS AND DISCUSSION

Tall Fescue Response. In mid-June, with the exception of pyrithiobac and drift rates of quizalofop-P and sethoxydim, each treatment significantly injured tall fescue (Table 1). By early August, all treatments injured tall fescue at least 17%. Peters et al. (1989) reported that 110 g/ha fluazifop-P and 220 g/ha sethoxydim injured seeded tall fescue 50 and 66%, respectively. The highest injury (88%) resulted from the early-June application of glyphosate. Herbicide injury to grass shoots may influence the filter strip's effectiveness and ability to withstand inundation from runoff (Dabney et al. 1993b).

All treatments reduced tall fescue harvested biomass by at least 30% (Table 1). Similarly to visual injury results, the reduction in tall fescue harvested biomass was highest (66%) from the early-June glyphosate application. With the exception of glyphosate applied in early June, herbicide effects on harvested biomass did not differ between drift and registered rates for any specific herbicide. Thus, within the year of exposure, drift rates of these herbicides were just as detrimental to tall fescue growth as labeled rates.

Switchgrass Response. In mid-June, drift rates of paraquat, glyphosate, MSMA, and pyrithiobac did not significantly injure switchgrass (Table 2). However, with all other treatments, switchgrass injury was 9 to 66%. The highest injury resulted from glyphosate applied in mid-April. By early August, the drift rate of paraquat was the only treatment that did not injure switchgrass. The highest injury observed in early August resulted from labeled rates of fluazifop-P, quizalofop-P, and sethoxydim, which was 64 to 71%. On the basis of visual injury observations, herbicide contact with a switchgrass filter strip should be avoided when weed control programs include glyphosate or graminicides.

Reductions in switchgrass harvested biomass were 15 to 62% (Table 2). Although no visual injury was observed in early August from the drift rate of paraquat,

Table 2. Effect of drift and registered[a] rates of selected herbicides on switchgrass injury and biomass production.[b]

Application timing	Herbicide	Rate	Visual injury		Harvested biomass[c] reduction
			Mid-June	Early August	
		g ai/ha	%		
Mid-April	Glyphosate	280	22	14	15
		1,120	66	40	42
	Paraquat[d]	176	0	0	24
		706	26	21	39
Early June	Clethodim[e]	26	13	40	31
		105	20	48	41
	Fluazifop-P	39	13	47	46
		158	37	71	62
	Glyphosate	280	6	22	39
		1,120	24	46	59
	MSMA	280	0	9	30
		1,120	22	21	46
	Pyrithiobac	17	0	9	23
		70	12	21	40
	Quizalofop-P	14	14	43	35
		56	37	64	58
	Sethoxydim	70	9	32	33
		280	27	66	50
LSD (0.05)			9	9	17

[a] Rates based on registered rates used in cotton.
[b] Means averaged over years.
[c] Based on 10,650 kg/ha biomass production for the untreated check.
[d] Nonionic surfactant at 0.25% (v/v) included in spray mix with paraquat and pyrithiobac.
[e] Crop oil concentrate at 1.0% (v/v) included in spray mix with clethodim, fluazifop-P, quizalofop-P, and sethoxydim.

Table 3. Effect of drift and registered[a] rates of selected herbicides on eastern gamagrass injury and biomass production.[b]

Application timing	Herbicide	Rate	Visual injury		Harvested biomass[c] reduction
			Mid-June	Early August	
		g ai/ha	%		
Mid-April	Glyphosate	280	39	28	29
		1,120	82	48	59
	Paraquat[d]	176	9	6	35
		706	13	19	42
Early June	Clethodim[e]	26	18	25	40
		105	29	44	67
	Fluazifop-P	39	21	38	49
		158	39	79	72
	Glyphosate	280	24	41	45
		1,120	46	79	71
	MSMA	280	26	39	35
		1,120	49	60	77
	Pyrithiobac	17	19	19	20
		70	31	31	61
	Quizalofop-P	14	19	22	38
		56	38	58	60
	Sethoxydim	70	13	26	47
		280	25	37	68
LSD (0.05)			8	11	20

[a] Rates based on registered rates used in cotton.
[b] Means averaged over years.
[c] Based on 8,970 kg/ha biomass production for the untreated check.
[d] Nonionic surfactant at 0.25% (v/v) included in spray mix with paraquat and pyrithiobac.
[e] Crop oil concentrate at 1.0% (v/v) included in spray mix with clethodim, fluazifop-P, quizalofop-P, and sethoxydim.

by the fall, switchgrass harvested biomass was reduced 24%.

Eastern Gamagrass Response. In mid-June, all treatments evaluated injured eastern gamagrass (Table 3). The mid-April glyphosate application resulted in 82% eastern gamagrass injury. Thus, if eastern gamagrass filter strips are used in a cotton production system, caution must be exercised with preplant and at-planting burndown glyphosate applications. By early August, the drift rate of paraquat was the only treatment that did not significantly injure eastern gamagrass. The highest injury (79%) resulted from registered rates of fluazifop-P and glyphosate applied in early June. Again, these data indicate that herbicide contact with eastern gamagrass filter strips should be avoided.

Eastern gamagrass harvested biomass was reduced by the herbicides evaluated 29 to 49% and 59 to 77% from drift and registered rates, respectively (Table 3). Aerial applications in cotton, where a filter strip is included, may not be a viable option because of the susceptibility of eastern gamagrass to drift rates of cotton herbicides. Although visual injury in early August from the drift rate of paraquat was 6%, the subsequent reduction in harvested eastern gamagrass biomass was 35%.

Results from these data suggest that implementation of filter strip technology will not simply involve filter strip establishment and maintenance. Management decisions must be made to protect the filter strips from contact with herbicides used in the production system. Even when visual injury may not be observed, herbicide drift may still adversely affect a filter strips shoot development, which may influence effectiveness and longevity (Dabney et al. 1993b). Furthermore, because of the significant effect of herbicides at drift rates, aerial applications may not be suitable when using filter strip technology. Because filter strips are planted adjacent to the crop, producers may be limited to ground applications of herbicides to minimize herbicide drift. If herbicide injury necessitates frequent reestablishment of filter strips, this will pose an added cost to the producer. Farmers must seriously consider the advantages of vegetative filter strips. As concerns regarding ground and surface water contamination increase (Misra et al. 1996), producers must target their efforts toward minimizing this problem. Strides toward improving herbicide stewardship are essential for producers so that necessary herbicides remain on the market to control weeds and maximize yields. Also, producers may want to choose a particular filter strip species based on the herbicide program in the production system.

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